

CONSTRUCTION STANDARD SPECIFICATION**SECTION 16001****ELECTRICAL WORK****Part 1 - General**

1.1	Summary	2
1.2	Definitions	2
1.3	Submittals	3
1.4	Quality Assurance	4

Part 2 - Products

2.1	General	4
2.2	Conduit And Tubing	5
2.3	Conductors	5
2.4	Outlet, Junction/Pull Boxes	6
2.5	Wiring Devices	7
2.6	Safety Switches, Disconnects, And Fuses	7
2.7	Cabinets	8
2.8	Grounding And Bonding	8
2.9	Motors	9
2.10	Motor Controllers (Starters)	9
2.11	Lighting Fixtures	10

Part 3 - Execution

3.02	Installation - General	10
3.02	Conduit And Tubing Installation	10
3.13	Supports/Anchors	13
3.04	Conductors	14
3.13	Outlet, Junction/Pull Boxes	15
3.13	Wiring Devices	16
3.13	Safety Switches	16
3.13	Cabinets	17
3.13	Grounding And Bonding	17
3.13	Cutting And Patching	18
3.13	Painting	18
3.13	Interruption Of Electrical Utilities	18
3.13	Tests/Inspections	19

CONSTRUCTION STANDARD SPECIFICATION

SECTION 16001

ELECTRICAL WORK

PART 1 - GENERAL

1.1.SUMMARY

- A. Furnish all labor, materials, services, equipment and appliances to complete the installation of the complete electrical system in accordance with the specifications and Contract Drawings. The Work covered by this section of the specifications consists of performing all operations, including cutting, channeling, and chasing, necessary for the installation of the complete electrical system.
- B. Related Sections
 - 1. Section 01065, "Environment, Safety, and Health for Construction and Service Contracts".
 - 2. Section 09900, "Painting".
 - 3. Section 16475, "Primary System Safety Requirements".
 - 4. Section 16501, "Fluorescent Luminaires".
 - 5. Section 16514, "Electrical High Intensity Discharge (HID) Luminaires and Lamps".
 - 6. Section 16521, "Exterior Lighting Units".
 - 7. Section 16742, "Intra-Building Telecommunication New System"
- C. Related Drawings:
 - 1. E-0006STD – Standard Symbols List & General Notes.

1.2.DEFINITIONS

- A. SCO – Sandia Construction Observer
- B. SDR – Sandia Delegated Representative
- C. Sandia/NM – Sandia National Laboratories, New Mexico

1.3.SUBMITTALS

- A. Shop drawings shall be submitted where directed in Section 01330, "Submittal Procedures," and for all equipment furnished by Contractor with internal wiring and controls differing from Contract Drawings, or not shown on Contract Drawings.

Note: Control wiring shall not be installed before these drawings have been submitted and approved.

- B. The following requirements are in addition to specific submittals for individual systems or equipment:

1. Except where specifically exempt by directions on Contract Drawings, electrical or electronic devices and assemblies shall be furnished with complete wiring diagrams, sequence of operation, and communication interfaces with other devices.
2. Internal wiring shop drawings shall include complete elementary (ladder) type diagrams, plus complete wiring diagrams, showing wiring internal to the unit, in its relative location.
3. Programmable electrical or electronic devices, assemblies, or equipment shall be furnished with complete instructions and accessories for programming the unit, along with documentation of the initial furnished program, communication protocol, and sequence of operation.

- C. Shop drawings shall be required for any substituted equipment furnished by the Contractor which results in changes to control or power wiring as shown on Contract Drawings. This includes circumstances where substitute components, control schemes, or power wiring are presented and approved which cause a change in the:

1. Size, number, or type of wires.
2. Size of conduit and its routing.
3. Connection changes.
4. Sequence of operation.

- F. If any of the above changes occur, new shop drawings showing the following shall be submitted:

1. Elementary ladder diagram.
2. Conduit plan.
3. Wiring diagram.
4. Conduit identification schedule.
5. Sequence of operation.

- G. Drawings shall include each diagram or plan of Contract Drawings that is affected.

1. Drawings shall be provided of the same size as the original construction drawings, and shall be reproducibles.
 2. If the changes are minor and Contractor chooses so to do, a print of the original Contract drawing may be made and changes noted thereupon for approval. This drawing shall become part of the as-built documentation submitted near the conclusion of the work.
- J. Overcurrent Coordination: Where substitute overcurrent equipment and devices are proposed, Contractor shall be responsible for an overcurrent coordination study of all new equipment, including fuses, circuit breakers and overcurrent relays with other new and existing equipment.

1.4.QUALITY ASSURANCE

- A. The latest version of the following industry specifications and standards shall form a part of this Section, to the extent applicable:
1. Insulated Cable Engineers Association (ICEA)
 2. Underwriter's Laboratories, Inc. (UL)
 3. National Fire Protection Association Standards (NFPA)
 4. American National Standards Institute (ANSI)
 5. National Electrical Manufacturers Association (NEMA)
 6. International, national, state, and municipal construction codes as adopted, unless the Contract Documents specify a different code is to be used.
 7. Illumination Engineering Society of North America (IESNA)
 8. National Electrical Installation Standards (NEIS)
- B. All Work performed in accordance with the above specifications shall be in strict compliance with OSHA regulation 29 CFR 1926 Subpart N. Particular attention is directed to "Safety Related Work Practices" 1926.416 and "Lockout and Tagging of Circuits," 1926.417.

2. PRODUCTS

2.1.GENERAL

- A. All electrical materials shall be new and as listed by the Underwriter's Laboratories, Inc., or other nationally-recognized testing laboratory, for the intended application, unless specific exemption is made in the Contract Documents.
- B. All similar materials and equipment shall be the product of the same manufacturer, or listed as an assembly thereof.

- C. Materials and equipment shall be the standard product of manufacturers regularly engaged in the production of such material and shall be the manufacturer's current and standard design.

2.2.CONDUIT AND TUBING

- A. Rigid Steel Conduit: Rigid, threaded, thick-wall, zinc-coated on the outside and either zinc-coated or coated with an approved corrosion-resistant coating on the inside.
- B. Rigid Aluminum Conduit: not permitted unless specified on Drawings.
- C. Intermediate Metal Conduit (IMC): Rigid, threaded, light weight steel, zinc-coated on the outside and either zinc-coated or coated with an approved corrosion-resistant coating on the inside.
- D. Rigid Nonmetallic Conduit: Schedule 40, high impact PVC with 5,000 psi tensile strength at 73.4 degrees F., approved for 90 degrees C conductors.
- E. Electrical Metallic Tubing (EMT): Mild steel, zinc-coated on the outside and either zinc-coated or coated with an approved corrosion-resistant coating on the inside.
- F. Flexible Conduit: Commercial, galvanized steel; comply with UL 1, "Flexible Metal Conduit."
- G. Liquid-Tight Flexible Conduit: Flexible galvanized steel tubing with extruded liquid-tight, sunlight-resistant PVC outer jacket; comply with UL 360, "Liquid-Tight Flexible Steel Conduit."
- H. Expansion Fittings: Malleable iron, hot-dipped galvanized with factory installed packing and a grounding ring.

2.3.CONDUCTORS

- A. Unless otherwise noted, all conductors shall be annealed copper with minimum 98% conductivity and shall conform with the applicable standards of UL, ANSI, and ICEA.
- B. Branch circuit conductors shall not be smaller than No. 12 AWG copper wire.
- C. All conductors No. 8 and larger shall be stranded.
- D. Unless otherwise specified, the minimum size for Class 1 remote-control and signal circuits shall be No. 16 AWG and for Class 2 low-energy control and signal circuits shall be No. 20 AWG.
- E. The use of solid or stranded wire shall meet the equipment manufacturer installation requirements.
- F. Unless otherwise specified, all conductor insulation shall be type THHN or THWN for 600V and below. Other types of conductors shall be installed where shown on Drawings.

- G. Metal-clad cable (MC cable) may be used for branch circuit wiring of 120/208 volt receptacles, 120/277 volt lighting, and similar terminal loads such as valves, dampers, variable-air-volume units, etc., where it meets the following:
1. The cable shall be concealed in walls or above accessible ceilings.
 2. The cable may not be surface mounted.
 3. The cable's conductors shall be copper, minimum #12 AWG THHN, with green-insulated ground.
 4. The cable's conductors shall be color coded per SNL Standard Drawing E-0006STD.
 5. The cable's outer jacket may be aluminum or steel, and may further be coated with a PVC or similar jacket where required for the installation's conditions.
 6. The maximum number of conductors allowed in a single cable assembly is limited to five, including the neutral and ground conductors.
 7. MC cable may not be used for fire alarm devices and associated circuits.

2.4.OUTLET, JUNCTION, AND PULL BOXES

A. Outlet Boxes

1. Only zinc-coated or cadmium-plated sheet-steel boxes, of a class to satisfy the conditions for each outlet, shall be used in concealed work.
2. Boxes mounted on the outside of the building walls shall be cast construction, with threaded hubs and gasketed covers.
3. Switch, telephone, and receptacle outlet boxes shall not be less than 4 inches square, fitted with appropriate plaster rings, where necessary to set flush within the finished surface.
4. Outlet boxes for exposed work shall not be less than 4 inches square with appropriate covers for surface work. "Handy" boxes may be utilized in accordance with the NEC requirements. Cut-in boxes are allowed to be installed for non-exposed work.
5. Fixture outlet boxes on ceilings shall not be smaller than 4-inch octagonal type.
 - a. Fixture outlet boxes in concrete ceilings shall be of the 4-inch octagonal type, set flush with the finished surface.
 - b. Fixture outlet boxes in plaster or other similar type ceilings shall be fitted with open covers (plaster rings) set to come flush with the finished surface.
6. Each box containing an equipment grounding conductor serving motors, lighting, fixtures, or receptacles shall be provided with a grounding terminal.
 - a. NOTE: The grounding terminal shall be green colored.
7. A device plate shall be provided for each outlet to suit the device installed.

- a. All outlet cover plates on unfinished walls or on any surface mounted devices shall be of zinc-coated sheet metal, having rounded or beveled edges.
- b. Unless otherwise indicated, all plates on finished walls shall be of ivory-colored metal or heavy-duty (“unbreakable”) nylon.
- c. Screws shall be of metal with counter sunk heads with a finish to match the finish of the plate.
- d. The use of sectional device plates is not permitted.

B. Junction/Pull Boxes

- 1. Pull boxes shall be constructed of code-gage galvanized sheet metal not less than the minimum size recommended by the National Electrical Code.
- 2. Boxes shall be furnished with screw fastened covers unless otherwise specified.

2.5.WIRING DEVICES

- A. Receptacles: All receptacles shall be of the type shown on Standard Drawing E-0006STD, or as specifically described on the Drawings.

B. Light Switches

- 1. Light switches shall be Industrial Specification Grade (Commercial Specification Grade not allowed), fully-rated for 20 amps at 120/277 volts.
- 2. Where light switches with pilot lights are indicated in Drawings, provide switch as specified above with an integral neon or LED light which is illuminated when in the “ON” position, unless specifically noted otherwise.
- 3. Where 3-way or other special switches are required, they shall be by the same manufacturer and same quality as the single pole switches.

2.6.SAFETY SWITCHES, DISCONNECTS, AND FUSES

- A. Unless specified otherwise, all safety switches and disconnects shall be of the heavy-duty type.
 - 1. Safety switches and disconnects shall be NEMA Type HD and shall be horsepower rated if a motor(s) is served by the device.
 - 2. All exterior mounted switches shall be NEMA type 3R, gasketed, unless noted otherwise on the Drawings.
 - 3. Safety switches and disconnects shall be furnished with provisions for lockout-tagout (LOTO).
 - 4. Safety switches and disconnects shall include the manufacturer’s approved equipment grounding terminal or grounding kit.

- B. Contractor shall furnish a complete set of fuses for all switches where fuses are specified. Fuses shall be dual element, time-delay, class "R", rejection type, unless otherwise specified on Drawings.

2.7.CABINETS

- A. Cabinet boxes shall be constructed of zinc-coated sheet steel and shall conform to the requirements of Underwriter's Laboratories, Inc. Standard for Cabinets and boxes (UL #50).
 - 1. Trims and doors shall have a suitable primer coat and a finish coat of a color specifically designated.
 - 2. Each cabinet box shall be constructed with interior dimensions not less than those indicated on Drawings.
 - 3. Cabinet trim shall be fitted with hinged door and flush latch.
- B. Boxes shall be provided with a 3/4 inch exterior grade, one-faced "B" grade, or equal plywood backboard inside painted white unless otherwise specified on Drawings.
- C. Cabinets shall have their identification letters shown on engraved plastic plates as shown on Standard Drawing E-0006STD.

2.8.GROUNDING AND BONDING

- A. Grounding and bonding products, whether or not indicated on the Contract documents, shall be of sizes and ratings to comply with the NEC. Where types, sizes, ratings, and quantities indicated are in excess of NEC requirements, the more stringent requirements and the greater size, rating, and quantity indications govern.
- B. Grounding and bonding conductors shall be copper. Equipment ground conductors run with circuit conductors and grounding electrode conductor shall be insulated with green outer finish, unless noted otherwise on the Contract documents.
- C. Unless noted otherwise, all conductors No. 8 AWG and larger shall be stranded, Class B in accordance with ASTM B8.
 - 1. Uninsulated conductors shall be bare copper in accordance with ASTM B3, tinned in accordance with ASTM B33, or alloy-coated in accordance with ASTM B189.
 - 2. Use tinned or alloy-coated in corrosive environments.
- D. Grounding connectors shall be listed and labeled for grounding application. Connectors shall be high-conductivity, heavy-duty units.
 - 1. Compression Connectors: Shall comply with IEEE STD 837, ANSI/UL-467.
 - 2. Welded Connectors: Exothermic-welded type, in kit-form, and selected per manufacturer's written instructions.

- E. Ground rods shall be copper-clad steel with high-strength steel core and electrolytic-grade copper outer sheath, molten welded to core. The minimum rod size shall be 3/4 inch by 10 feet long.

2.9.MOTORS

- A. Exact motor specifications, when required, will normally be given in Division 15, Mechanical specifications. Therefore, coordination with mechanical Contractor is required.
- B. In addition to the above requirements, each motor shall be of sufficient size for the duty to be performed and shall not exceed the full rated load when the driven equipment is operating at specified capacity under the most severe conditions likely to be encountered.

2.10. MOTOR CONTROLLERS (STARTERS)

- A. All controllers shall conform to the adopted standards and recommended practices of the Industrial Control Standards of the National Electrical Manufacturers' Association and the Underwriter's Laboratories, Inc.
 - B. Each motor or group of motors requiring a single control shall be provided with a suitable controller and devices which will perform the functions as specified for the respective motors in other sections of these specifications.
1. Each motor, except those whose impedance is sufficiently high to prevent over heating due to failure to start, such as clock motors, shall be provided with overload protection, either integral with the motor or controller, or mounted in a separate enclosure.
 - a. Unless otherwise specified, protective devices shall be of the manual reset type. Manual controllers for motors, larger than 1/4 horsepower, shall be specifically designed for the purpose and shall have a horsepower rating adequate for the motor.
 - b. Where overloads are supplied with controllers, these shall be sized after receipt of the equipment to be protected in accordance with nameplate data.
 - c. Overload protection for substituted multispeed motors shall be arranged to protect all windings and shall be so designed that if an overload occurs in one winding, all windings will be disconnected simultaneously.
 - d. Motor controllers shall have LED type pilot lights as follows:
 - 1) The color for indicating motor is operating shall be red; for stopped shall be green, unless indicated otherwise on the Drawings or in the Motor Control Center Special Construction Specifications.
 - 2) Additional lights for low/high speed shall be included as indicated on the Drawings or in the Motor Control Center Special Construction Specifications.
 2. When automatic control devices such as thermostats, floats, or pressure switches are substituted by Contractor for specified devices, and they control the starting

and stopping of motors directly, they shall be designed for the purpose and have adequate horsepower ratings.

NOTE: When the automatic control device does not have such a rating, a magnetic starter shall be used with the automatic control device actuating the pilot control circuit.

2.11. LIGHTING FIXTURES

- A. Refer to Section 16501, "Fluorescent Luminaires", for all requirements concerning fluorescent lighting.
- B. Refer to Section 16514, "Electrical High Intensity Discharge (HID) Luminaires and Lamps", for all requirements concerning HID lighting.
- C. Refer to Section 16521, "Exterior Lighting Units", for requirements concerning exterior lighting.

PART 3 - EXECUTION

3.01 INSTALLATION - GENERAL

- A. No employer shall permit an employee to work in such proximity to any part of an electric power circuit that the employee could contact the electric power circuit in the course of work, unless the employee is protected against electric shock by de-energizing the circuit and grounding it or by guarding it effectively by insulation or other means.
- B. Fabrication, erection and installation per National Electrical Installation Standards and the complete electrical system shall be done in a first-class workmanlike manner by qualified personnel experienced in such work.
- C. Conduit and equipment shall be level, plumb and true with the structure and other equipment, and in a horizontal or vertical position as intended.
- D. The installation shall comply with all provisions of the National Electrical Code (NEC) (NFPA 70).
- E. Removals: Do not abandon in place, unless specified on Contract Drawings.
- F. Immediately prior to acceptance, Contractor shall clean all electrical equipment, both on the exterior and interior.

3.02 CONDUIT AND TUBING INSTALLATION

- A. Conduit systems that are 2" or larger, installed outdoors, and terminate on an exterior enclosure that houses an overcurrent device (circuit breakers or fuses) shall enter through the side or bottom.
- B. Electrical metallic tubing (EMT) shall not be installed in concrete, underground, or through roof penetrations. EMT may be used on the exterior of buildings unless otherwise specified on the drawings.

1. EMT shall utilize UL-listed water-tight compression-type threadless fittings in outdoor applications.
 2. EMT box connectors shall be securely fastened to all boxes and cabinets with one locknut.
- C. Rigid galvanized steel conduit (RGS) and intermediate metal conduit (IMC) shall be used where shown on Drawings, in outdoor locations, for roof penetrations, and where required to meet NEC requirements. For roof penetrations extend RGS and IMC a minimum of 12" above the roof membrane. Rigid and intermediate metal conduit shall be securely fastened to all boxes and cabinets with two galvanized locknuts and one bushing installed wrench tight.
- D. Polyvinyl Chloride (PVC) or other types of conduit may be used only where specified on Drawings.
1. When used underground but not under a building floor slab, provide minimum three inch concrete cover at bottom, four inch at top, and minimum of four to a maximum of six inch cover at sides of conduit or ductbank.
 2. A mandrel 1/4" - 3/8" smaller than the conduit shall be pulled through each conduit. A circular wire brush the same diameter of the conduit then shall be pulled through the conduit.
 3. Conduit stub outs shall be RGS or IMC capped and not encased in concrete for future accessibility. Capping shall be installed to prevent moisture or debris from entering the duct system.
- NOTE: All bends, except for communication and high voltage duct banks, shall be of steel, unless specified otherwise on Drawings.
- E. Flexible conduit shall be used for motor, equipment connections or where specified on Drawings and then only to the extent of maximum lengths of 6 feet for connections.
1. Install flexible conduit connections at all resilient-mounted equipment.
 2. Provide liquid-tight flexible conduit in exterior, wet or damp locations, for connections to wet-pipe mechanical systems or where specified on Drawings.
 3. All installations in demountable metal partitions (Dowcraft, VMP) shall be run in flexible metallic conduit or MC cable to a junction box located above the panel.
 4. Final connection to lighting inverters shall be made with flexible conduit.
- F. All EMT, IMC, and rigid conduit couplings will be installed wrench tight; threads shall be brushed clean to ensure good electrical contact.
- G. Install insulating type bushings, designed to prevent abrasion of wires without impairing the continuity of the conduit grounding system, on rigid steel conduit, IMC and rigid aluminum conduit larger than 1/2-inch size.
1. Insulated bushings shall be installed on all raceways for conductors No. 4 and larger at the point of entry into gutters, cabinets, boxes, or motor control centers.

- H. Conduits and tubing shall be concealed within the walls, ceilings, and under the floors where possible, as shown on Drawings. Maintain at least 6 inches distance from parallel runs of flues, steam pipes, or hot water pipes.
- I. Conduits concealed within interior walls shall be run vertically to the maximum extent possible, excepting only those instances where the architecture does not permit it (such as an expanse of contiguous windows with receptacles below).
- J. Conduit, cable and tubing systems installed above lay-in ceilings shall be installed as high as possible above the ceiling with runs parallel or perpendicular to walls, structural members, or intersections of vertical planes and ceilings, with right-angle turns, consisting of cast-metal fittings or symmetrical bends. However, this placement shall be coordinated with other disciplines in this space so as to permit ready access to connections, boxes, and equipment, including removal and replacement of separate covers and swing clearance for hinged covers without removal of other disciplines' equipment.
- K. Exposed conduits shall be run parallel and perpendicular to the building surface of exposed structural members and follow the surface contours as much as practical to present a neat appearance. Exposed parallel or banked conduits shall be run together to provide neat appearance.
- L. Bends and Offsets shall be avoided where possible, but when necessary, shall be made with an approved hickey or conduit-bending machine. The use of pipe tee or vise for bending conduit or tubing will not be permitted. Only UL listed PVC benders shall be used to bend PVC.
- M. Conduit or tubing which has been crushed, wrinkled, or deformed in any way shall not be installed.
- N. Each conduit that is buried in or rigidly secured to the building construction on opposite sides of a building expansion joint and each long run of exposed conduit that may be subjected to excessive stresses shall be provided with an expansion fitting suitable to the degree of expansion expected.
- O. Contractor shall exercise the necessary precautions to prevent the lodgment of dirt, plaster, or trash in conduit, tubing, fittings, and boxes during the course of installation.
 - 1. Care shall be taken to ensure that raceways do not contain any type of debris.
 - 2. A run of conduit or tubing, which has become clogged, shall be entirely freed of these accumulations, or shall be replaced.
- P. All empty conduits shall have a conduit measuring tape cord (Greenlee #435) provided with 2 feet of slack at each end, unless otherwise shown on plans.
- Q. No holes for conduit installation will be allowed in steel or reinforced concrete structural members unless approved by the Sandia Construction Observer (SCO).
- R. All underfloor or underground conduit runs shall be installed such that, as a minimum, the last thread is exposed at least ¼" above the finished floor including miscellaneous slabs, interior grade beams, finishes, and other portions of the floor.
- S. Conduit shall not be installed within a concrete slab.

- T. All conduit under building floor slabs shall be installed a minimum of 12 inches below the bottom of the slab, with a compacted fill between. If the underfloor conduit is PVC, additional protection of 3 inches of concrete shall be emplaced on the conduit as the lower part of the compacted fill.
- U. All steel conduits installed in direct contact with the earth shall receive a protective covering which shall be mechanically applied as hereinafter indicated.
 - 1. One application, half-lapped, of Minnesota Mining and Manufacturing Company "Scotchwrap" No. 51, Plymouth Rubber Co. "Plywrap 20" or Westape, Inc. 20 mil Pipe Wrap shall be applied. A "Scotch Coat" No. 101 pipe coating resin treatment will also be accepted.
 - a. All elbows or bends shall have the wrap applied after the conduit is bent.
 - b. Fittings shall have two separate applications of Minnesota Mining and Manufacturing Company "Scotchwrap" No. 51, Plymouth Rubber Co. "Plywrap 20" or Westape, Inc. 20 mil Pipe Wrap, half lapped.
 - 2. Conduit shall be not covered with backfill until the installation approval is obtained from the SCO.
- V. See Standard Drawing E-0006STD for conduit color coding requirements.
- W. Conduit or tubing risers shall be exposed in air shafts or ducts only when approved.
- X. Exposed lengths of conduit, containing medium voltage power conductors, and operating at more than 600 volts shall be rigid steel conduit. Paint two 1/2-inch wide red bands spaced 6 inches apart near each coupling, with the operating voltage stenciled in 1/2 inch letters between the bands.

3.03 SUPPORTS/ANCHORS

- A. Runs of conduit or tubing shall have supports spaced not more than 5 feet apart, unless shown otherwise.
 - 1. Conduit and tubing shall be supported on approved types of galvanized wall brackets, ceiling trapeze, strap hangers, or pipe straps, secured by means of toggle bolts on hollow masonry units, expansion bolts in concrete or brick, machine screws on metal surface, and wood screws on wood construction. Conduit and tubing shall not be hung from or attached to hanger support wires used for suspended ceilings.
 - 2. Conduit and tubing risers exposed in utility shafts shall be supported at each floor level by means of approved U-clamp hangers.
 - 3. Holes for electrical supports drilled in concrete but which are not used shall be properly filled with concrete grout.
 - 4. The cutting of structural members for the installation of supports shall not be permitted except by prior written approval from the SCO.
 - 5. Conduit or conduit supports shall not be welded directly to steel structures.

6. Wooden plugs inserted in masonry or concrete shall not be used as a base to secure conduit supports.
 7. Nails shall not be used as the means of fastening boxes or conduits.
 8. Wire or perforated strapping shall not be used for the support of any conduit or tubing.
 9. Conduits, conduit supports and associated boxes shall not be attached to roof joist bridging.
- B. All metal angles, channels, straps, and other similar pieces to be used to support electrical apparatus shall have all corners ground smooth and all edges filed or ground smooth before installation.

3.04 CONDUCTORS

- A. Power conductors shall be continuous from outlet to outlet, and no splices shall be made except within outlet or junction boxes. (Junction boxes shall be utilized where required).
1. Requirements of the NEC (2005) Articles 374.6 and 390.6, for splicing in underfloor raceways, shall be strictly followed. However, under no circumstances shall conductors be "Looped" or "fed-through." Conductors shall be removed back to the nearest used tap. NEC (2005) Articles 374.7 and 390.7 for abandoned outlets shall also be strictly followed.
 2. Conductor color coding as per Standard Drawing E-0006STD shall be limited to all new installations unless otherwise specified on Drawings.
- B. Except where approved by the SCO, no splices will be allowed in control wiring.
- C. Splices and Terminations
1. For wiring below 600 volts, splices shall be made with insulated pressure type connectors (wire nuts) except for conductors sized No. 8 and larger. No splices will be allowed on any alarm, communication or facility control systems.
 2. All splicing connectors shall be furnished with an insulated cover that is equivalent to the conductor insulation. (Taping alone will not be acceptable.) Split bolt connectors will only be allowed where specific approval for each use is obtained prior to use from the SCO.
 3. A connector aid compound shall be used at all splices to existing aluminum wire.
 4. Terminal lugs shall be used on all stranded conductors.
 5. A Belleville spring washer shall be used where existing aluminum, terminals are connected to copper or steel terminals with steel bolts.
 6. High voltage splices and terminations shall be as specified or according to recommendations of wire supplier. Splices shall be made only in the presence of the SCO.
- D. Conductor Identification

1. All conductors in panels shall be tagged, including neutral and ground conductors. Install a Bradey slip on label on conductors sized less than # 6 AWG and install a Panduit #MP-350C tag and tie wrap on conductors sized # 6 AWG or larger. Use a Panduit marking pen PX-O or a Sharpie permanent marker for labels. These tags shall list the circuit number.
 2. All conductors shall be additionally tagged in every box and cabinet, including device or fixture (lighting) outlet, and light fixture compartment, with Brady slip on labels. Wrap around stick on labels are allowed only where slip-on labels cannot be used. These labels shall identify each conductor as to panel and circuit number or terminal numbers.
 3. Neutral and grounding conductors shall be similarly tagged as to all the circuits they serve in each box and at the panelboard.
 4. Computer rooms and all other areas where an isolated ground conductor is required shall have the ground conductor similarly identified (tagged) as to all the circuits they serve in each box.
 5. Box covers shall not be installed until approval has been obtained from the SCO for tagging at each box.
- E. Provide UL-listed pulling compound for conductor pulling.
- F. Equipment used for pulling conductors shall be suited and listed for such use by the manufacturer.
- G. When used, MC and similar cable assemblies shall be installed per NEC Article 330. Where MC cable is concealed in walls, it must be run vertically to accessible ceiling, not horizontally through walls. MC cables may not be used for exposed surface applications, nor for panel feeders. Only the use of a manufacturer's approved tool is allowed to cut the cable. All such cables shall have a green insulated ground conductor; bare-metal grounds shall not be used.

3.05 OUTLET, JUNCTION/PULL BOXES

- A. Boxes shall be installed in a rigid and satisfactory manner, either by wood screws on wood, expansion shields on concrete or filled masonry, or machine screws or self-tapping screws on steel work.
- B. Outlet Boxes
1. Outlet boxes shall be installed in the locations shown on Drawings.
 - a. Unless otherwise noted on the plans, the exact locations for outlets shall be obtained by scaling Drawings.
 - b. Dimensions shall be taken from the nearest fixed portion of the building, such as a cross wall or column line, or other similar part of the structure.
 2. Device Plates
 - a. Plates shall be installed with four edges in continuous contact with finished wall surfaces, without the use of mats or similar devices.

- b. Plates shall be installed vertically and with an alignment tolerance of 1/16 inch.
- c. Plates installed in wet locations shall be approved for that use.
- d. All receptacle device plates shall be labeled per Standard Drawing E-0006STD. Label to include panel and circuit number.

3. Relocations

- a. If outlets are located improperly by more than 6 inches from the locations shown on the plans, they shall be removed and reinstalled in proper locations at no additional cost to SANDIA/NM.
- b. Contractor shall study the general building plans in relation to the spaces surrounding each outlet in order that his work may fit the Work required by these specifications.
- c. When necessary, Contractor shall relocate outlets so that when fixtures or other fittings are installed, they will not interfere with other work or equipment.
 - 1) When these relocations are required, the SCO will record this new location upon his record plan and on Contractor's plan in red pencil.
 - 2) Contractor will also initial and date both plans.
- d. Junction/Pull Boxes for communication systems shall be installed per Section 16742, "Intra-Building Telecommunications New System"

3.06 WIRING DEVICES

A. Receptacles

- 1. All receptacles shall be installed as specified on Drawings and as per Standard Drawing E-0006STD.
- 2. Not more than one conductor shall be installed under one receptacle termination point.

B. Wall Switches

- 1. All wall switches shall be installed as specified on Drawings and as per Standard Drawing E-0006STD.
- 2. Not more than two switches shall be installed in a single gang position of a switch box.
- 3. Not more than one conductor shall be installed under one termination point.

3.07 SAFETY SWITCHES

- A. Safety switches shall not be used as pull boxes or junction boxes, unless otherwise noted on Drawings.
- B. All safety switches shall have a label affixed per Standard Drawing E-0006STD. The label shall identify the circuit feeding the safety switch and the equipment served by the safety switch.
- C. Safety switches, fusible and non-fusible, shall be installed to comply with the minimum working clearance dimensions of NEC article 110.26 and table 110.26 (A)(1).

3.08 CABINETS

- A. Mount cabinets plumb and rigid without distortion of box.
- B. Arrange flush mounted cabinets so that the enclosure front surface is uniformly flush with wall, and exterior door covers wall to enclosure mating surfaces. Provide for future circuits as shown on Drawings.
 - 1. If not shown on drawings, stub a minimum of four one-inch (25mm) empty conduits from cabinet into accessible ceiling space or space designated to be ceiling space in future.
 - 2. If not shown on Drawings, stub a minimum of four one-inch (25mm) empty conduits into raised floor space, or below slab other than slabs-on-grade.
- C. All surface mounted cabinets located on finished walls within office and light laboratory areas shall be furred from the floor to the ceiling to provide a chase for conduits. The panels used for furring shall be removable by sheet metal screws or wood screw attachment or a similar method.

3.10 GROUNDING AND BONDING

- A. As a minimum, grounding and bonding shall comply with NFPA 70 (NEC), and as shown on Drawings. Grounding and bonding shall also comply with the following:
 - 1. UL 467 "Grounding and Bonding Equipment"
 - 2. Applicable IEEE Standards such as IEEE 142 "Recommended Practice for Grounding Industrial and Commercial Power Systems".
- B. Grounding electrode shall include ground rods, driven exterior to the facility or as shown on Drawings.
 - 1. Top of ground rods shall be driven to a minimum depth of 2 feet (0.61 m), unless noted otherwise. Locate ground rods a minimum of two-rod lengths from each other and at least the same distance from any other grounding electrode.
 - 2. Interconnect ground rods with bare ground conductors.
 - 3. In additional equipment ground conductor shall be run with circuit conductors. See Standard Drawing E-0006STD for more grounding requirements.

- C. Make connections in such a manner as to minimize possibility of galvanic action or electrolysis. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
 - 1. Use electroplated or hot-tin-coated materials to assure high conductivity, and make contact points closer in order of galvanic series.
 - 2. Make connections with clean bare metal at point of contact.
 - 3. Coat and seal connections involving dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
- D. Terminate insulated equipment grounding conductors for feeders and branch circuits with UL-approved grounding lugs. Where metallic raceways terminate at metallic housings without mechanical and electrical connection to the housing, terminate each conduit with a grounding bushing.
 - 1. Connect grounding bushings with a bare grounding conductor to the ground bus in the housing.
 - 2. Bond electrically non-continuous conduits at both entrances and exits with grounding bushings and bare grounding conductors.

3.11 CUTTING AND PATCHING

Work shall be carefully laid out, in advance, and where cutting, channeling, chasing, or drilling of floors, wall partitions, ceiling, or other surfaces is necessary for the proper installation, support, or anchorage of the conduit, raceways, or other electrical work, the affected areas shall be repaired by skilled mechanics of the trades involved, at no additional Contract cost.

3.12 PAINTING

Electrical items shall be painted in accordance with requirements of Section 09900, "Painting."

3.13 INTERRUPTION OF ELECTRICAL UTILITIES

- A. Work to be performed during an interruption of electrical utilities will be preceded by all possible preparation and will be carefully coordinated to minimize the duration of the interruption and Work will proceed continuously until the system is restored to normal.
- B. Contractor shall not interrupt any main interior or exterior electrical utility without written request for an outage and subsequent approval by SNL; nor shall the Contractor interrupt any branch circuit to an outlet or item of equipment without verbal approval from the SCO.
 - 1. Written request for outages shall be submitted using the Outage Request Worksheet, according to the instructions and advance notice requirements on the Worksheet.

2. Unless otherwise noted on Drawings, or directed, any tie-ins or connections to existing utilities or equipment that necessitate interruptions of service shall be performed on a Saturday or Sunday, without additional Contract costs.
- C. Unless otherwise directed, the manipulation of existing main valves to isolate piping, the shutdown of fans, pumps, and other equipment will be done by Sandia/NM maintenance personnel.

3.14 TESTS/INSPECTIONS

After the system installation is complete and at such time as directed by the SCO, Contractor shall conduct an operating test for demonstration of completion of the work. This test may be in addition to and part of a formal system commissioning procedure, but shall not replace such commissioning event.

- A. Also, when requested, Contractor shall test any designated wire, cable devices, and equipment after their installation, to assure that all of the material continues to possess all the original characteristics, as required by all governing codes and standards listed in these specifications.
- B. At the time of the operational testing a complete set of as-built drawings shall be given to the SCO.

END OF SECTION 16001